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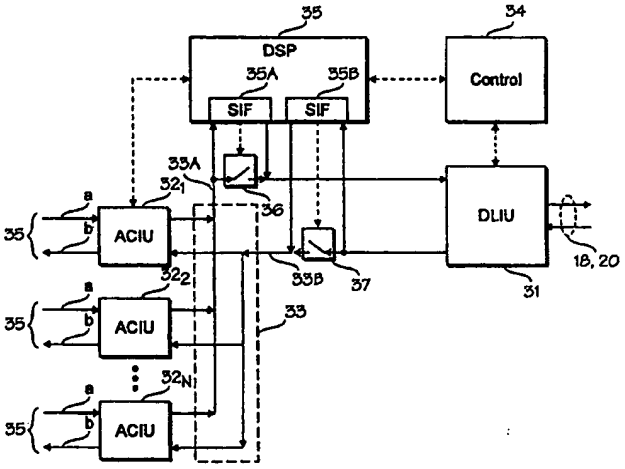
(54) Title: AN APPARATUS FOR INTERFACING A MULTI–CHANNEL DIGITAL LINK AND A PLURALITY OF ANALOG LINES




(57) Abstract

The invention relates to an apparatus for interfacing a multi–channel digital link and a plurality of analog lines in telephone systems. A TDM bus system (33) is provided between a digital link interface circuit (31) and analog line interface circuits (32) for transferring user information signals in two directions. A multi–channel digital signal processing unit (35) is connected to the TDM bus system (33) for selectively signal processing the information signals transferred on the TDM bus system. Which information signals are selected for signal processing and which signal processing function is performed on each specific selected information signal is determined by a software of the apparatus. The apparatus is very flexible and scaleable, as it is very easy to add, modify or completely change the signal processing functions by a simple software change without redesigning and changing the hardware. Typical functions could be analog inband signalling processing, voice equalization, echo cancellation, echo suppression, tone suppression, dual–tone multi–frequency (DTMF) detection and DTMF generation.

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# An apparatus for interfacing a multi-channel digital link and a plurality of analog lines

## Field of the Invention

The invention relates to telephone systems and, more particularly, to signal processing functions in association with analog line interfaces.

## Background of the Invention

Digital exchanges (switches) are nowadays widely used in public switched telephone networks but the subscriber lines between the exchange and the subscriber facilities are typically analog two-wire lines. Therefore the digital exchange may be provided with an analog subscriber interface which interfaces the digital signal from the digital exchange to the analog subscriber line. In Fig. 1 an exchange 10 is provided with an analog subscriber interface 11 which connected to a subscriber line 13 from subscriber terminal 12. As shown in Fig. 1, an analog subscriber interface 15 may also be located at a remote multiplexer unit 14 which is interconnected with a digital subscriber interface 19 in the exchange 10 by a digital link 18 (e.g. 2 Mbit/s). As further illustrated in Fig. 1, a digital link 20 may also interconnect a remote multiplexer 16 with another multiplexer 21 located close to the exchange 19. The analog interface of the multiplexer 21 is connected to the analog subscriber interface in the analog exchange 10. Use of the multiplexers and the digital links enable longer distances between the subscribers and the exchange as compared with use of pure analog lines. It is further possible to locate the multiplexer close to the subscriber premises, which allows to realize the access network in a star configuration with short subscriber lines and thereby with relatively low costs of cabling.

A number of analog subscriber interfaces in a multiplexer (such as multiplexers 14, 16 and 21) is often very high, because the digital link is normally at least 2 Mbits/s multi-channel PCM (Pulse Code Modulation) link. This means capacity of 30 subscriber channels and two signalling channels in minimum.

In a prior art multiplexer a high speed PCM link is handled with a relatively simple multiplexing device which is common to all analog subscriber interfaces. A time division multiplexed (TDM) bus is provided for transfer of

information between the multiplexing device and the analog subscriber interfaces.

Modern telephone networks and digital exchanges support various functions and features which were not available in conventional analog exchanges. For example, echo cancellation is widely used for improving the speech quality, especially in long distance and international calls. Dual-tone multi-frequency (DTMF) generation and detection allow tone dialling and thereby various services. It is desired that various new functions could be offered also to the subscriber of conventional exchanges without major hardware changes in the exchanges or in the multiplexers.

In countries in which the digitalization of the telephone networks is still going on or has not yet been started, there may be generations of analog exchanges which support different kinds of functions and signalling. A new digital exchange or a multiplexer should be able to provide an analog interface having functions compatible with analog inter-exchange lines and subscriber lines in each specific case. Also introduction of new functions or features typically requires designing a new hardware for the multiplexing unit.

**Disclosure of the Invention**

Thus, an object of the invention is a multiplexer apparatus or a like which allows to modify or completely change signal processing functions without need to changes in the hardware.

This and other objects of the invention are achieved by an apparatus for interfacing a multi-channel digital link and a plurality of analog lines, comprising

a digital link interface unit connected to said multi-channel digital link for two-way transmission of user information and signalling information,

analog channel interface units, each of the analog channel interface units being connected to one or more analog lines of said plurality of analog lines,

a time division multiplexed (TDM) bus system for two-way transfer of information signals between said digital link interface unit and said analog channel interface units,

a multi-channel digital signal processing unit connected to said TDM bus system for selectively signal processing said information signals transferred on said TDM bus system.

In an apparatus according to the invention, a TDM bus system is provided between a digital link interface circuit and analog line interface circuits for transferring user information signals in two directions. A multi-channel digital signal processing unit is connected to the TDM bus system for selectively signal processing the information signals transferred on the TDM bus system. Which information signals are selected for signal processing and which signal processing function is performed on each specific selected information signal is determined by a software of the apparatus. The apparatus is very flexible and scaleable, as it is very easy to add, modify or completely change the signal processing functions by a simple software change without redesigning and changing the hardware. Also additional analog lines can be added without hardware modifications. Tailored signal processing functions can be easily provided for each single application with the same universal hardware, which will significantly reduce the cost of development and manufacture. A further advantage of the invention is that it allows use of conventional analog line interface circuits and digital link circuits, since the signal processing unit is connected to the bus system between them. Typical applications could be analog inband signalling processing, voice equalization, echo cancellation, echo suppression, tone suppression, dual-tone multi-frequency (DTMF) detection and DTMF generation.

**A Brief Description of the Drawings**

The apparatus in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 illustrates various ways to realize a subscriber access network in an analog or digital local exchange,

Figure 2 is a basic block diagram of an apparatus according to the invention.

**A Detailed Description of the Invention**

The present invention can be applied in various apparatuses interfacing a multi-channel digital link and a plurality of analog lines. A typical ap-

plication is a remote subscriber multiplexer, such as multiplexer 14, 16 or 21 in Figure 1. Another typical application may be interexchange trunk lines provided by the a pair of the inventive apparatuses between a pair of exchanges. The apparatus according to the invention may be physically located in an exchange. In the preferred embodiment of the invention described below the apparatus is a remote multiplexer.

Referring to Figure 2, the multiplexer according to the preferred embodiment of the invention comprises a digital link interface unit (DLIU) 31 and a plurality of analog channel interface unit (ACIU) $32_1...32_N$. Each ACIU 32 may provide an interface to one or more analog two-wire line 35. ACIU 32 separates audio-frequency (voice-frequency) transmit and receive direction signals. An analog-to-digital conversion (e.g. analog-to-PCM conversion) is performed on the receive direction signal before transmitting it to the DLIU 31. Similarly a digital-to-analog conversion (e.g. PCM-to-analog conversion) is performed on a PCM signal received from DLIU in order to provide a transmit direction signal which is fed to the analog line 35.

The DLIU 31 is connected to a high speed digital link, which may be a 2 Mbit/s or higher speed PCM link. At the far end of the digital link 18 or 20 may be, for example, a digital exchange (such as exchange 10 in Figure 1) or another multiplexer (such as the multiplexer 21 in Figure 1). In the preferred embodiment of the invention DLIU 31 is a multiplexing unit which provides a 2 Mbits/s interface according to CCITT standard G.704.

The multiplexer apparatus further comprises an internal time division multiplexed (TDM) bus system 33 to which the ACIUs 32 and the DLIU 31 are connected. In the preferred embodiment of the invention the timing and management of the TDM bus system 33 is located to a control block 34. The control block 34 allocates, permanently or dynamically, time slots in the TDM bus system 33 for transferring user information between ACIUs 32 and the DLIU 31. The user information as used herein means generally any speech or data information or inband signalling of the analog line 35 transferred through the TDM bus system 33. The user information is typically in form of PCM samples. The TDM bus system 33 may consist of one or more discrete buses, serial or parallel. TDM bus system 33 includes also a signalling channel for transferring signalling and control information between ACUs 32 and the DLIU 31. The signalling channel may be in form of one or more time slots in a TDM bus or as a separate signalling bus. It should be noted that the detailed struc-

ture and operation of the TDM bus 33 is not relevant to the present invention and will not be described in more detail herein. In the preferred embodiment shown in Figure 2 the TDM bus system 33 comprises a receive direction TDM bus 33A and a transmit direction TDM bus 33B.

In accordance with the principles of the present invention, a digital signalling processing unit 35 is connected to the TDM bus system 33 for selectively signal processing the information signals transferred over the bus system 33. In the preferred embodiment of the invention a decoupling circuit 36 is series connected on the serial receive TDM bus 33A. The input port and the output port of the serial interface 35A in the DSP unit 35 is connected to the input and output of the decoupling circuit 36, respectively. The decoupling circuit 36 is controlled by the DSP unit 35 to switch a direct connection through the decoupling device 36 so as allow the information signals on the TDM bus 35A to go straight to the DLIU 31, or to break the direct connection in order to route the information signals to pass through the DSP unit 35 to be signal processed before being forwarded to DLIU 31. Similarly, a decoupling circuit 37 is series connected on the serial transmit TDM bus 33B. The input port and the output port of serial interface 35B in the DSP unit 35 is connected to input side and output side of the decoupling circuit 37, respectively. The decoupling circuit 37 is controlled by the DSP unit 35 to switch a direct connection between the DLIU 31 and the ACIUs 32 in order to allow the information signals on the TDMA bus 33B to go straight to the ACIUs 32, or to disconnect the direct connection in order to route the information signals to pass through the DSP unit 35 in order to be signal processed before being forwarded to the ACIUs 32. In the preferred embodiment of the invention the decoupling circuits 36 and 37 are controlled selectively for each time slot in the TDM buses 33A and 33B. Thereby, each information signal transferred over the TDM bus system 33 can be selectively processed or left unprocessed. The serial interfaces 35A and 35B provide a serial-to-parallel and parallel-to-serial conversions between the parallel data format of the DSP unit 35 and the serial data format of buses 33A and 33B. The DSP unit 31 performs a real time signal processing independently for each information signal (or analog line signal 35) to be processed. By a suitable programming of the DSP unit, any possible data processing can be selected for the information signals. If needed, a different kind of signal processing can be selected for every single information signal (or ACIU 32). Typical signal processing performed in DSP unit 35 may include

analog inband signalling processing, voice equalization, echo cancellation, echo suppression, term suppression and/or dual-tone-multi-frequency (DTMF) detection and DTMF generation. However, the invention is not intended to be restricted any specific voice band signal processing. The primary object and advantage of the present invention is that any signal processing can be easily added to, removed from or modified in the DSP unit 35 by solely changing the software of the DSP unit 35, without requiring any hardware changes. Therefore, no specific signal processing method will be described in more detail herein. Typical signal processing methods, such as echo cancellation, are well-known in the art.

The DSP unit 35 may be connected to the TDM bus system 33 in many ways different from the one described above. For example, all the information signals may be routed through the DSP unit 35, and the DSP unit 35 decides whether the specific user information signal is processed or passed through without processing.

Further, additional ACIUs 32 can be connected to the TDM but system 33 without requiring any hardware changes for signal processing. Similarly, extra ACIUs 32 can be removed from the apparatus.

Although particular embodiments of the invention and variations thereof have been described in detail, it should be appreciated that numerous other modifications, variations, and adaptations may be made without departing from the scope of the invention as defined in the claims.

**Claims**

1. An apparatus for interfacing a multi-channel digital link (18,20) and a plurality of analog lines (35), comprising

a digital link interface unit (31) connected to said multi-channel digital link (18,20) for two-way transmission of user information and signalling information,

analog channel interface units ($32_1$-$32_N$), each of the analog channel interface units being connected to one or more analog lines of said plurality of analog lines,

a time division multiplexed (TDM) bus system (33) for two-way transfer of information signals between said digital link interface unit (31) and said analog channel interface units ($32_1$-$32_N$),

a multi-channel digital signal processing unit (35) connected to said TDM bus system for selectively signal processing said information signals transferred on said TDM bus system (33).

2. The apparatus as claimed in claim 1, wherein said TDM bus system comprises means for dynamically routing information signals in any selected one or ones of time-slots in said TDM bus system (33) via said multi-channel digital signal processing unit (35).

3. The apparatus as claimed in claims 1 or 2, wherein said multi-channel digital signal processing unit (35) is capable of providing dedicated signal processing for each specific information signal channel.

4. The apparatus as claimed in claims 1, 2 or 3, wherein said signal processing includes one or more of the following functions: analog inband signalling processing, voice equalization, echo cancellation, echo suppression, tone suppression, dual tone multiple frequency (DTMF) detection and DTMF generation.

5. The apparatus as claimed in any one of the preceding claims, wherein said analog lines (35) comprise subscriber lines.

6. The apparatus as claimed in any one of the preceding claims, wherein said analog lines (35) comprise interexchange trunk lines.

Fig. 1

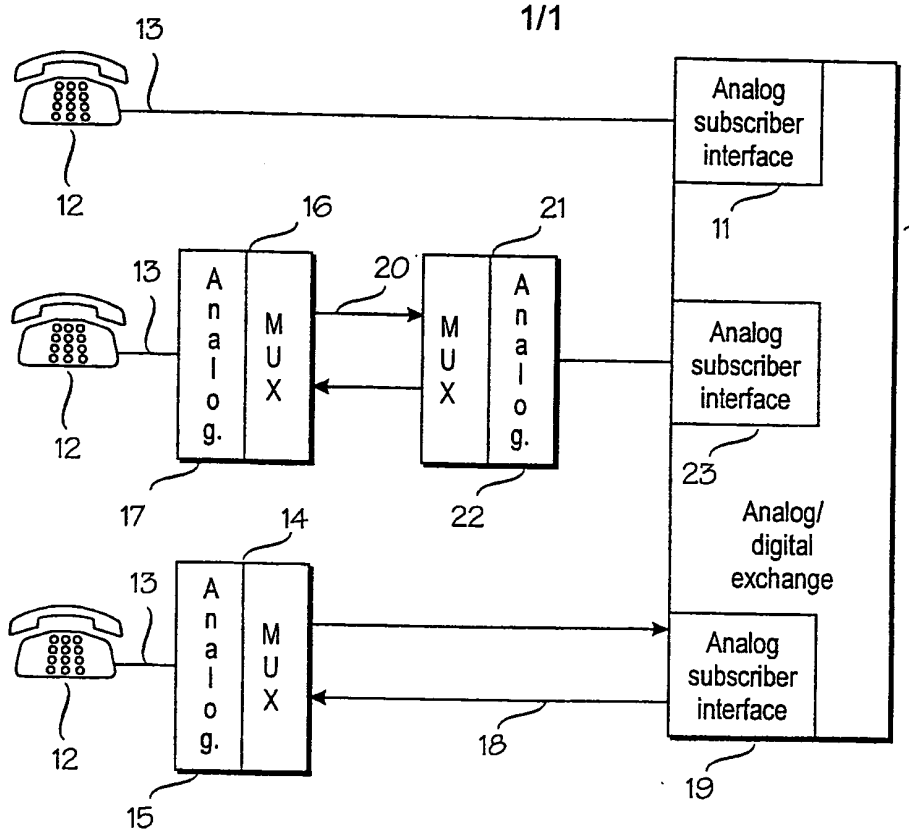
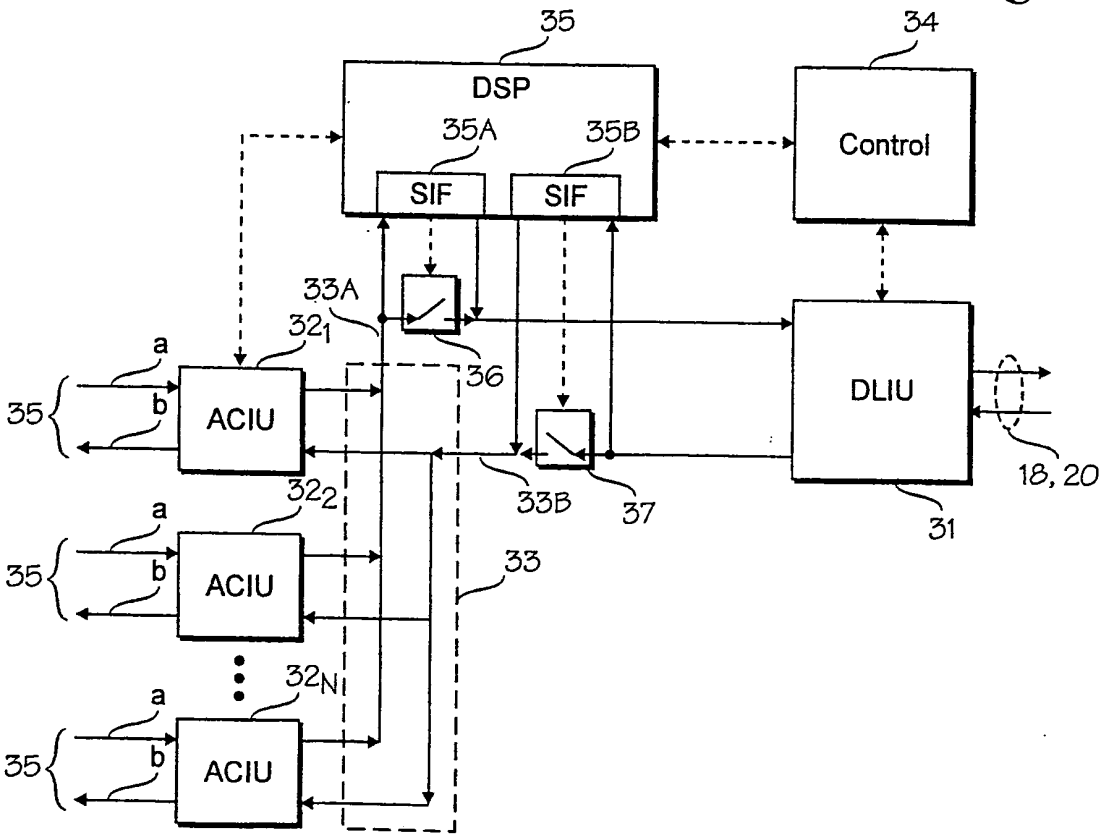

13
12
Analog subscriber interface
11
10
16
21
13
20
Analog
MUX
MUX
Analog
12
Analog subscriber interface
23
17
22
Analog/ digital exchange
14
13
Analog
MUX
12
Analog subscriber interface
18
15
19

Fig. 2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Control
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# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00998

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 11/04
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IPC6: H04Q, H04M

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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| A | GB 2185657 A (STC PLC), 22 July 1987 (22.07.87), see the whole document | 1-6 |
| A | US 4178479 A (JOHN C. MCDONALD ET AL), 11 December 1979 (11.12.79), see the whole document | 1-6 |
| A | US 4366566 A (JEAN-YVES COCHENNEC), 28 December 1982 (28.12.82), see the whole document | 1-6 |

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Information on patent family members

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